REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-00-

0470

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
		1 April 1996 - 31 December 1997

4. TITLE AND SUBTITLE
A Knowledge-Based Assistant and Tutor for Managing Hazardous Waste

5. FUNDING NUMBERS
F49620-96-1-0120

6. AUTHOR(S)
Prof Bruce Porter

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Department of Computer Sciences
University of Texas at Austin
Austin, TX 78712

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR
801 North Randolph Street, Room 732
Arlington, VA 22203-1977

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
F49620-96-1-0120

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for Public Release.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The focus of our research is the efficient construction of large, multi-purpose knowledge bases. Initially, we focused on developing automated methods of building knowledge bases - this is critical for all future research on large knowledge bases. This lead to automated methods of building knowledge bases by the process of automatically composing together components. This work was awarded the Best Paper Award at the National Conference on Artificial Intelligence in July 97.

20000929 051

14. SUBJECT TERMS	15. NUMBER OF PAGES
	3
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

Final Technical Report for AFOSR grant F49620-96-1-0120

Bruce Porter
Department of Computer Sciences
University of Texas at Austin
Austin, Texas 78712
porter@cs.utexas.edu

1 Overview

The focus of our research is the efficient construction of large, multi-purpose knowledge bases. Initially, we focused on developing automated methods of building knowledge bases – this is critical for all future research on large knowledge bases. This lead to automated methods of building knowledge bases by the process of automatically composing together components. This work was awarded the Best Paper Award at the National Conference on Artificial Intelligence in July 1997.

Building on these results, we have focused on several new issues:

1. We have addressed the problem of representing planning operators (domain-specific knowledge about the effects of actions in a domain) for use by AI planning systems. We have developed a novel approach in which domain-specific operators are represented as a composition of general components, and we show that the problem of manually building a detailed set of operators can be avoided by constructing them from a small number of such components instead. Each component encapsulates information about a domain feature that might be modeled, and each may contribute to several operators. Moreover, our research describes how the choice of what to model and what to ignore in a domain can then be easily varied, simply by controlling which components are used. Finally, we show how operator sets built in this way can be used by planning algorithms.

2. Conceptual Graphs (CGs) are a natural and intuitive notation for expressing first-order logic statements. However, the task of performing inference

with a large-scale CG knowledge base remains largely unexplored. Although CGs provide basic inference operators (such as type expansion and contraction), few methods are available for guiding their application during automated reasoning. Given the expressive power of CGs, this can result in inference being intractable.

In our research we showed how a method used elsewhere for achieving tractability — namely the use of access paths — can be applied to conceptual graphs. Access paths add to CGs domain-specific information that guides inference by specifying preferred chains of subgoals for each inference goal. Inference with access paths is based on access-limited logic, which, although incomplete, retains a weakened form of completeness called Socratic Completeness, and guarantees polynomial-time inference. The result of this work is an inference algorithm for CGs that significantly improves the efficiency of reasoning.

3. Natural kinds, such as the concepts "toy block" or "photosynthesis", are ubiquitous in human reasoning yet lack definitional (i.e., individually necessary and jointly sufficient) properties as membership conditions. We want to represent a wide variety of assertions about these natural concepts with precision and logical consistency. Furthermore, we want to be able to verify that the meaning of each concept does not conflict with the constraints implied by its constituents. Classification-based approaches to these tasks have relied on definitional properties in order to deduce subsumption and thus detect inconsistency. These approaches are inapplicable for building representations of natural concepts. Our solution to these problems is twofold. First, we build KBs by iterative refinement; i.e., the KB is constructed through a sequence of editing operations. Second, we define practical, yet formal, properties of concept satisfiability and inheritance that each operator is guaranteed to preserve. When the user builds representations of concepts using the operators, guard procedures ensure that existing concepts are used in a manner consistent with their meaning. We also discuss the computational complexity of guarding consistency, and the characteristics of the system that we believe make these computations practical in an interactive setting.

2 Software Produced

During the period of this grant, we developed a new knowledge-representation language, KM, that facilitates building large, multifunctional knowledge bases. We distribute the software freely over the internet. See: `http://www.cs.utexas.edu/users/mfkb/km.html`

3 Personnel Supported

The following personnel were supported by this project or were associated with it:

1. Bruce Porter (Associate Professor)
2. Art Souther (Research Scientist)
3. Peter Clark (Post-doctoral Researcher)
4. Jeff Rickel (PhD graduate student)
5. Rich Mallory (PhD graduate student)
6. Stevel Correl (PhD graduate student)

4 Publications

The following peer-reviewed publications were produced during the period of the grant:

(with Lester, J.), "Developing and Empirically Evaluating Robust Explanation Generators: The KNIGHT Experiments", Computational Linguistics Journal, 23(1), pp. 65–101, 1997.

(with Rickel, J.), "Automated Modeling of Complex Systems to Answer Prediction Questions", Artificial Intelligence Journal, 93(1-2), pp. 201–260, 1997.

(with Clark, P.), "Building Concept Representations from Components", Proceedings of the National Conference on Artificial Intelligence, pp. 369–376, 1997 *Best Paper Award.*

(with Clark, P.), "Using Access Paths to Guide Inference with Conceptual Graphs", Proceedings of the Fifth International Conference on Conceptual Structures, 1997.

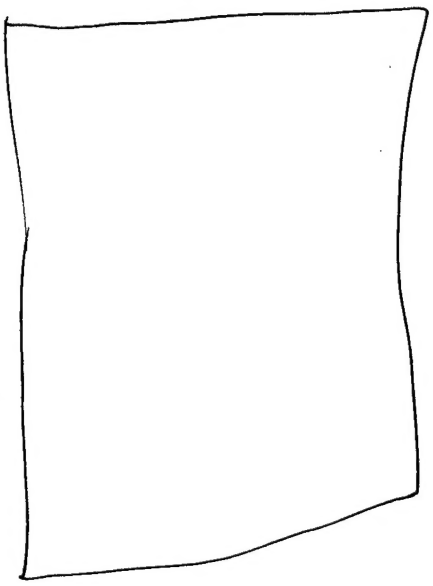
"Comprehending Complex Behavior Graphs through Abstraction", Richard Mallory, Bruce Porter, and Ben Kuipers, *Proceedings of the International Workshop on Qualitative Reasoning about Physical Systems*, 1996.

5 Interactions and Transitions

Interactions. During the period of the grant, we have interacted with the TRAIN group at Brooks AFB in San Antonio. The purpose of this interaction was to explore ways of applying data mining to the databases built by that group.

In addition, Bruce Porter served as one of six "faculty mentors" for the Doctoral Consortium held during the 1997 National Conference on Artificial Intelligence.

Transitions. The results of our research have
Inc. The Research group at Boeing (contact: Dr.
tifunctional knowledge bases containing informati



6 Inventions and Patents

None.

7 Honors and Awards

Appointed Presidential Young Investigator by the
1988–1993.

*** DTIC DATA ***

P. R. NUMBER: FQ8671-9700250
PROPOSAL NUMBER: 96NM135 (located 6135f, page 2)
TYPE SUBMISSION: Final Report
INST. CONTROL NUMBER: F49620-97-1-0013
INSTITUTION: Cornell University
P.I. NAME: Professor Fred Schneider
INVENTION IND: NONE
PROJECT/TASK: 2304 FS
PROGRAM MANAGER: MAJOR DAVID LUGINBUHL
****

1. Objective:@36.1@UNARR. ------ OBJT.

!!To gain a deeper understanding of computer systems through: investigation of a new model for distributed systems that is more suitable where communications links may fail and where survivability against malicious attacks is important, and identification of systems principles have broad applicability in all systems implementations.

2. Approach:@37.1@UNARR. ------ APPR.

$$The investigators have been instrumental in the design of mobile agent system, TACOMA, that will be the basis for research into mobile agents as a means of providing distributed systems infrastructure. One of the primary problems to be examined is how to protect computations from malicious hosts and how to protect hosts from faulty or malicious agents. Investigators will examine cryptographic approaches for the agent integrity problem and stage compilation for the host integrity problem. The investigators also intend to isolate and characterize systems techniques and principles that span many subdisciplines of computer science with a view towards enabling their uses in new systems and settings. Certain principles (e.g., caching), appear in many system contexts (computer memory, files, network ad- dressing). By identifying these principles and understanding them at a level that transcends a particular system context, we can instantiate them in new contexts and contribute to system-building technology.

3. Progress:@38.1@UNARR. ------ PROG. - FROM 15 DEC 96 TO 14 DEC 99